ON JAPANESE PIGMENTS

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CONTENTS.

I. WHITE PIGMENTS.

		Page.
1.	Oshiroi (White Lead)	2
2.	Gofun (Chalk	7
3.	Keifun (Calomel)	8

II. RED PIGMENTS.

1.	Beni (Safflower)	10
2.	Shu (Vermilion)	15
3.	Tan (Red Lead)	17
4.	Bengara(Red oxide of iron)	19
5.	Shudo („)	20
6.	Taishasumi („)	20
7.	Shoyenji (Carmine)	21

III. BLUE PIGMENTS.

1.	Ai (Indigo)	23
2.	Konjo (Blue Carbonate of Copper)	27
3.	Hanakonjo	29

IV. GREEN PIGMENTS.

1.	Rokusho (Green carbonate of Copper)	31
2.	Dōroku (Verdigris)	31

V. YELLOW PIGMENTS.

		Page.
1.	Shiwo (Gamboge)	32
2.	Sekiwo (Orpiment)	32
3.	Zumi Paste	33
4.	Odo (Yellow oxide of Iron)	34

VI. BLACK PIGMENTS.

1.	Sumi (Lamp black or Ind. Ink)	35

ENAMEL COLOURS.

1.	Used for the Shippo-ware in Kioto.	39
2.	„ „ „ Kutani Porcelain-ware in Kaga	43
3.	Used for the Rakuyaki	45

ON JAPANESE PIGMENTS.

The subject which I propose to consider in the present essay is one of the most interesting matters in practical chemistry while it is most important for those whose profession is that of painting, though our pigments are comparatively few in number, and mainly consist of natural products of very simple composition.

So far as time has permitted, I have endeavoured to study these compounds as practically as possible and to give analytical results in addition to their history, methods of preparation, uses &c. but there are some points which at present can not be given in detail and must be supplied on a future occasion.

I have divided Japanese pigments, including those imported from China, into six-classes according to their colours, and those employed for enamels are specially given in the last part of this paper.

I. WHITE PIGMENTS.

In this class we have

1. Oshiroi (White Lead)
2. Gofun (Chalk).
3. Keifun (Calomel).

1. OSHIROI.

The use of this substance as a cosmetic is said to have originated in Japan under the Tenno, Jito. In the 6th year (695 A. D.) of her reign a priest named Kuanjo made himself a specimen of *Oshiroi*, and presented it to her majesty, the Empress, who gave him in return 15 *hiki* of silk, 30 *tan* of cotton and 50 *tan* of cotton cloth.

It seems, however, that the manufacture was commenced at a much later time, about 250 years ago, by a merchant of the province of Idzumi; thence it was spread to Kioto and Osaka, of which the former is now the main place where the manufacture is carried out on a large scale. It is highly probable that the present method of making Oshiroi was derived from China, in as much as it resembles in its main features the process that is carried out in that country, where it is said to have been made more than 2000 years ago.

The following is a brief account of the process carried out in Mr. Murakawa's Oshiroi works in Kioto, which we had the opportunity of visiting in the February of this year.

Here we found a number of furnaces used for the manufacture, each consisting of a common platform *a* of brick work, about 1 *shaku* above the ground, provided with a recess *b* for a small earthen-ware furnace *c (Hichirin)* which contains charcoal fire. Over this a coarse kind of earthen dish *d* is suspended from the level of the platform, in such a way that no communication is allowed between the recess and the space above the dish, which holds vinegar to be volatilized. Above the recess is placed an inverted tub, about 2.7 *shaku* in height, which has no bottom, but is provided at its centre with a grating of bamboo, which allows the vapour of vinegar to pass through, thus bringing it in

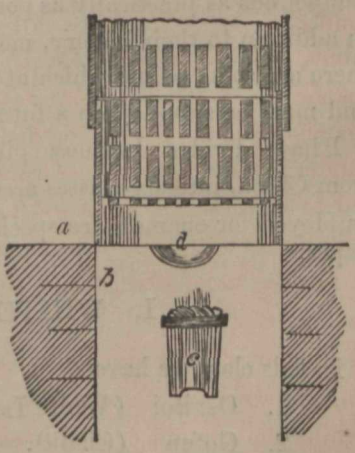

Fig. 1.

contact with the rolls of metallic lead placed upon it.

As the lower part of the tub is a little wider than the upper part, the second one can be fixed on the first, and the third on the second, and so on to the height of 4 or 5 tubs, that is 11 or 12 *shaku* from the level of the platform, the space between their joints being carefully filled with clay so as to prevent the escape of acid vapour into the surrounding atmosphere. The metallic lead used for this purpose comes from France in the form of pigs. It is first melted in an iron pan, and poured upon a cast iron mould 6 *sun* broad and 8 *sun* long having a shape somewhat like that shown in fig. 2. When the lead is cooled at the cold surface of the mould, the upper part which still remains liquid is poured off, and the thin sheets of lead thus produced is taken out and rolled up into a spiral form.

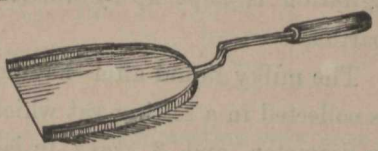

Fig. 2.

A number of these rolls are packed vertically within the first barrel, and when full, another one is placed and filled with lead as before, and so on to the upper most one which is closed at the top with a well fitting cover, while the edge and ioints are coated with paper by means of *funori*.

We found 21 of such furnaces in the work arranged in a line and some at right angles, all of them being charged at the same time. There is a small opening in the front side of the lowest barrel just below the bamboo grating, through which weak vinegar is introduced into the dish which is heated by a charcoal fire underneath. The temperature of the furnace is carefully regulated by a workman, so as not to evaporate more than the required amount of vinegar. The temperature we found at the bottom of a furnace to be 132° F, and that at the top 114° F, the difference being 18° F.

The amount of vinegar consumed per day in each furnace during the working is about 7 *sho* which is added at 5 equal intervals, whilst the amount of lead in each furnace is nearly 200 *kuanme* at a time. After 20 days from the beginning a workman examines

the interior of each furnace by removing the cover at the top, and if a white coating is already formed on the lead, he then stops heating and allows the whole apparatus to cool.

The contents are now taken out from the upper part of the furnace, each roll of lead being beaten as it comes out with a small rod, in order to remove the scale of white lead as far as possible from the unacted-upon portion of the metal. The white powder thus obtained is placed under water contained in large tubs, where agitation is kept up by wooden poles so as to reduce it to fine particles.

The milky liquid after having been passed through fine seives is collected in a setting vat which is made of wood, about 3 *shaku* in diameter, and 3 *shaku* in height, and provided at its centre with a cylinder of bamboo gauze covered with fine cloth, so that no solid particles would pass into the interior of the cylinder whilst the water entering therein is removed from time to time by means of a syph·n. This affords, therefore, a good means of facilitating the drying operation, and the thick paste formed is then placed in square boxes of earthen ware, about 7 *sun* sq. and 2.5 *sun* in height, which should be so porous and dry, that the water is absorbed with great rapidity They are piled upon one another in the manner repsesented in fig. 3, and dried in the shade for a certain length of time.

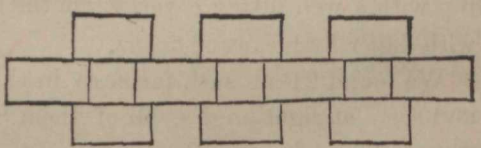

Fig. 3.

The partially dried mass is now cut into a number of small squares by means of a sharp knife, and is further dried near the furnace which is at work. When all the moisture has been expelled each cake is folded in paper and sold under the name of *Ki-oshiroi* (pure oshiroi) or *Tōnotsuchi* (Chinese earth) which is the first quality of white lead.

An inferior quality is made either from the residue left in the vats or from that part which could not be separated from the lead

by simply beating. These are ground in stone mills, passed through a sieve, and sobjected to levigation and drying as before. The metallic lead which was left unchanged may be used for subsequent charges in the middle part of a furnace.

Now with regard to the composition of the finished product I analysed a few samples of *Tönotsuchi*, taken from thess works, and obtained the following average result:—

Oxide of lead (PbO)	86.42
Carbonic acid (CO_2)	11.60
Water (H_2O)	2.00
	100.02

This analysis shows that it approaches in composition very nearly to that prepared by the Dutch and German methods and consequently has the formula $2\ Pb\ CO_3 + Pb\ (\ HO\ )_2$.

But from the description of the apparatus it may be asked, Where was the carbonic acid derived from, constituting such a large percentage of the compound? It has already been remarked that no communication existed between the recess and the space above the dish containing the vinegar so that it was impossible for the products of combustion of charcoal to enter into the main part of the furnace, where the actual conversion was going on, except through accidental holes or crevices in the partition or any other part of the furnace.

Or, could it come from the decomposition of the acetic acid employed? Let us calculate the real amount of acetic acid expended during one operation, which takes at least 20 days. Since the 21 furnaces require 1.5 *koku* of vinegar per day it will amount in 20 days to 30 *koku*, or about 1448 *kuanme*. But according to analysis made by Mr. Ota, a student in the 3rd year chemistry class, the strength of the vinegar used was such that a liter contained 9.42 grams of pure acetic acid ($C^2\ H_4\ O_2$), which he determined from the distillate by means of standard solution of ammonia. Now assuming the specific gravity of its aqueous solution to be the same as that of water, which is very nearly the case, the

percentage amount of the acetic acid would be .942: hence the total weight of pure acetic acid in 1448 *kuanme* of the vinegar becomes 13.64 *kuanme* for the amount of white lead produced in one operation that is 2000 *kin* or 320 *kuanme*.

Referring to Ure's Dictionary under the head of White Lead we find the theory that in the Dutch process of making white lead, hexa-basic acetate of lead ($Pb\ (C^2\ H_3\ O_2)_2\ .5\ PbO$) is first formed and subsequently decomposed by slow combustion into water and carbonic acid, which combining with 4 molecules of plumbic oxide leaves a compound exactly the same as white lead. According to this theory then, one molecule of acetic acid ($C^2\ H_4\ O^2$ eq. 60) corresponds to one molecule of white lead ($2\ Pb\ CO_3 \cdot PbO$, eq. 757) so that 13. 64 *kuanme* of the former would produce 170. 3 *kuanme* of the latter, but the amount of white lead actually obtained, as we have seen, is almost double that calculated from the above hypothesis. Hence we see that, even supposing this theory to be correct, there must be a sufficient quantity of carbonic acid derived from some other source, and there appears at present no other way to account for this other than leakage of the gas into the apparatus, and if so, it is a strange fact that an important constituent of the body should be derived from an accidental source. Indeedt it necessarily follows that the method should be altered in some way or other for the more successful conduct of the operations.

With regard to the price of several qualities of white lead produced in the same works, the best one, which is not mixed with any other substance, is sold for 20 *sen* per *kin*, and the next quality for 18 *sen* per *kin*. They are called by the same name, *Tonotsuchi*, which is mainly used for an essential ingredient of porcelain enamels, to which I shall refer afterwards, and also as a cosmetic by most women and actors.

White lead is mixed with pure starch (called *ukiko*) in the proportion of 7 to 10 for the production of other kinds of powder known under the general name of *Oshiroi*. It must be remenbered that the term *Oshiroi*, although it includes the pure white lead in its original meaning, is usually restricted to the mixed powder,

and that the starch is added not as an adulteration, but simply as a diluent, hence it is more extensively used as a cosmetic particularly on the face than *Tonotsuchi*, which is too caustic for that purpose. Neither of these kinds of white lead is used for general painting as it darkens on the exposure to air.

I now give an analysis of a specimen of *Oshiroi*, prepared by Mr. Murata in Tokio, by simply adding starch and small amount of a scent, to *Tonotsuchi*, which comes from Kioto :—

White lead ($2\,PbCO_3 + Pb(HO)_2$).....	47.5
Starch + perfuming matter	52.5
	100.0

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2. GOFUN.

This substance is manufactured extensively in the province of Idzumi, where the process is conducted as follow :— About 40 *kuame* of oyster-shells, which have been kept for a long time in the open air, are placed in a box, 3 *shaku* long, 2 *shaku* wide and 2 *shaku* high, which is made to rotate for 4 hours by water power, so as to remove all their outer coatings ; this process being called kairai or shell washing.

The cleaned shells are crushed in a stone mortar by the action of a metallic pestle, and after being sifted are again reduced to a fine powder in a series of mortars the pestles of which are moved by water power, and lastly subjected to levigation, using a similar apparatus described in case of *Oshiroi*. The carbonate which has settled to a pasty mass is now dried, either by spreading on a board, or filling into a mould ; in the former case the product is called *Hirate*, and in the latter case *Jingasate*.

The residue which was left in the washing tubs is called *Nezumi-kaki*. and may be used for medicinal purposes. In the production of the finest *Gofun* the shells must be so old as to have been exposed to the open air for 10 years, while for the inferior qualities half a year's exposure is sufficient.

The amount of *Gofun* produced in this district for one year is 100.000 *kuanme* costing 3200 *yen*. It is very extensively employed for wall painting as, unlike white lead, it is unaltered in the air, while white lead also is very much dearer than *Gofun*. It is also used in painting to give various tints by mixing it with other colours.

I have examined a specimen of the best quality of *Gofun*, and found it to be very pure consisting of 99.5 % of Ca CO_3.

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3. KEIFUN

According to old history this substance was very early known even in the year 714 (the 6th year of Wado) when it was presented to the empress Gemmiyo from the province of Ise.

Up to the present time it has been manufactured only in that province, hence it is also called *Ise Oshiroi*, which possessing important medicinal properties is mostly used for that purpose rather than as a pigment.

The mode of preparation is the following :— A mixture of 2 parts of alum, 1 part of mercury, and 1 part of common salt is well pulverized in a mortar until no globules of mercury can be seen. The mass is then placed in a iron pot covered with an earthen ware cover, which is carefully luted up by means of a mixture made from wood ashes and salt water. At Izawa, in the province of Ise, where the manufacture is now carried out, the shapes of the iron pot and cover are something like those shown in fig. 4. The pot is here called *Hozukigama*, and is 5 *sun* in diameter, 5 *sun* in height, while the cover is simply called *Hozuki* having about an equal diameter.

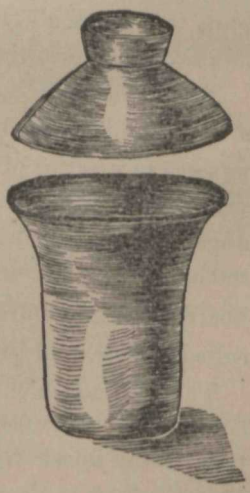

Fig. 4.

36 of such pots are placed in a rectangular furnace, and gradually heated by a charcoal fire for some time, meanwhile the covers are moistened with water. In this way about 2 parts of the calomel can be obtained from 1 part of mercury, subliming on the inner surface of the cover as a white crystalline powder like snow. It is said that inferior qualities are often adulterated with gypsum, nitre, mica powder &c, but a specimen I examined was quite pure, almost no residue being left on ignition. It is sold at 5.2 yen per *kin* in Tokio.

When sublimed two or three times by the same process the calomel is called *Funso*, which is said to be much purer than ordinary *Keifun*.

With regard to the Chemical reaction which takes place during the manufacture of the calomel it appears probable that the mercury is partly oxidized forming mercuric oxide which combines with the sulphuric acid expelled from the alum by the action of heat, thus forming mercuric sulphate. This compound being decomposed by sodic chloride finally produces calomel, or mercurous chloride by excess of mercury as may be represented by the following equation : $2\ Al_2(SO_4)_3 + 12\ Na\ Cl + 6\ Hg_2 + 3O_2 = 6\ (Na_2\ SO_4) + 6\ (Hg_2\ Cl_2) + 2\ Al_2\ O_3$.

In some prescriptions nitre is added to the mixture, so that the oxidation of mercury is no doubt assisted.

II. RED PIGMENTS.

Under this class we shall consider the following substances :—

1. Beni (safflower).
2. Shu (vermilion).
3. Tan (red lead).
4. Benïgara (red oxide of iron).
5. Taishasumi, ,,
6. Shudo ,,
7. Shoyenji (carmine).

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1. BENI.

The safflower plant, or carthamus tinctorius grows in many parts of Japan, but the best quality is produced from Yamagata in the province of Ugo, where it is largely cultivated. In this district there are three kinds of plants : the 1st is called *Azamibotan*, which grows high, bearing many flowers, but on account of its having a number of prickles on its stems it is very difficult to collect without injuring the fingers ; the 2nd is called *Oshimebotan*, which also grows well, but the quality of the safflower is rather inferior to the first kind ; while the 3d. is called *Koshimebotan*, which does not grow to the same extent as the former kinds, and consequently bears a smaller number of flowers, although the quality is said to be better than that of the others.

The seeds produced from these three kinds may be distinguished from one another by their different colours, the first one being white, the second gray, while the third is brown. Of these the middle kind is almost exclusively cultivated on account of the harmless nature of the plant itself, as well as of yielding a profitable amount of flowers from a given area of ground.

For cultivation, the seeds are first steeped in water for a few days, and after drying in the air they are sown during the middle of March. After 14 or 15 days buds will appear above the ground. They are allowed to grow for 5 days, then some of the

young shoots are taken off from the rest in order to make the latter grow more freely than otherwise. This operation is usually repeated 3 times within a certain interval, and each time their roots are carefully coated with earth so as to protect them as much as possible from any external injuries.

The plant begins to blossom at the end of June having at first a golden yellow colour, which gradually turns to a beautiful red hue. When this point has been reached women and children are engaged to collect the flowers by picking them off between their fingers in the early morning or best on a rainy day, this work being usually continued till the middle of summer. The amount of the flowers thus collected will vary according to the nature of the ground, and the conditions of the culture in different places, but on an average 30 *kuanme* are obtained from 1 *tan* or 300 *tsubo* of ground. In order to prepare it in the form of small lumps it is put in a tub, and washed with water four or five times so as to remove the greater part of the useless matter, the pulp thus obtained being now placed in a basket, again treated with water, and lastly exposed to the sunshine. The partially dried mass is then cut into a number of round cakes, about 1 *sun* in diameter, and 2 *sun* thick, which are placed on a moistened mat, laid in a box (6 *shaku* long, and 3 *shaku* wide) till they are four or five *sun* high. Above this another piece of mat is laid down which is also moistened with water forming the second bed of another layer of cakes, and so on to the extent of five layers, pressure being given each time by the feet of the workmen.

A little water is now sprinkled over them every morning for 3 or 4 days until the mass becomes very soft, when they are dried by exposure to sunshine, and preserved till sent into commerce. They are then put in paper bags, each of which contains 500 *momme*, and every bag of 64 is sold at different prices according to the quality of cakes, and the places where they are produced, as may be seen in the following table —

A TABLE SHOWING LOCALITIES, AND PRICE OF SAFFLOWER CAKES.

	Province.	Kori.	Mura.	Price of 32 kuname.
The Best Class.	Rikuzen.	Miyaki.	Funaoka. Okawara. Otani	180 yen.
	Musashi.	Iruma.	Nishiyama.	180 „
	Iwashiro.	Ibaraki.	Fujii. Tatani. Tomura. Kunii.	150 „
	Uzen.	Mogami	Tosuke-shinden. Matsuzawa. Tanichi.	130 „
The Middle Class.	Rikuchu.	Iwai.	Morioka.	150 „
	Musashi.	Iruma.	Omiya. Ageo. Urawa. Okegawa. Yamagata.	160 „
	Iwashiro.	Ibaraki.	Ota. Sakanouye.	120 „
	Uzen.	Murayama.	Tateoka. Tendo. Tamgawa.	110 „
The Lowest Class.	Rikugo.	Mito.	Nambu.	100 „
	Iwashiro.	Ibaraki.	Shishito.	100 „
	Shimosa.	Katsushika.	Furukawa.	140 „
	Ugo.	Tagawa.	Shoda. Akita.	90 „

The above table is compiled from a note by Mr. Tatekawa of Kioto, to whom I owe the following information regarding the method of extracting carthamine, the colouring matter of safflower, from such cakes, producing what is known as *Komachibeni*, and *Saikubeni*, and also the mode of dyeing with safflower as is carried out extensively in his works, which we visited in February of this year (1878).

An aqueous solution of an alkali, and some organic acid, such as is obtained from unripe plums, are the materials used in the extraction of carthamine. The lye is made by repeated exhaustion of straw ash with water to such an extent that a *hiyo* containing 3.5 *to* of the ash will yield 3 *to* of the alkaline liquid. The acid is produced from the unripe plums obtained at Iga, and from Yamashiro. They are gently roasted in an earthen dish by means of a charcoal fire underneath, whereby water is expelled, causing shrinking of the fruit to a certain degree. They are further dried in the sunshine, and kept until required. The plums so obtained are called *Yakiume*, and cost 7 yen per *koku*. When the acid is required they are exhausted with water, and the strength should be such that 8 *sho* of the acid solution would be produced from 1 *to* of the roasted plums.

Having thus obtained these two reagents I have now to describe the mode of extracting the colouring matter. 1500 *momme* of the safflower cake are placed in a large tub, and steeped in water for one night, then washed four or five times with water so as to remove the soluble yellow colouring matter as much as possible, which would otherwise spoil the red colour of the carthamine. The washing liquid is usually poured over a mass of ropes made of *asa* (hemp) which takes up a small amount of the carthamine contained in it; this is extracted from time to time, when a sufficient amount has been collected.

The washed mass is then put into a number of bags made of *asa*, about 2.5 by 2 *shaku* in size which are placed one above another on the bed of a pressing apparatus, resembling in the main part of its construction that used for *Sake*-making as the annexed figure 5 will show.

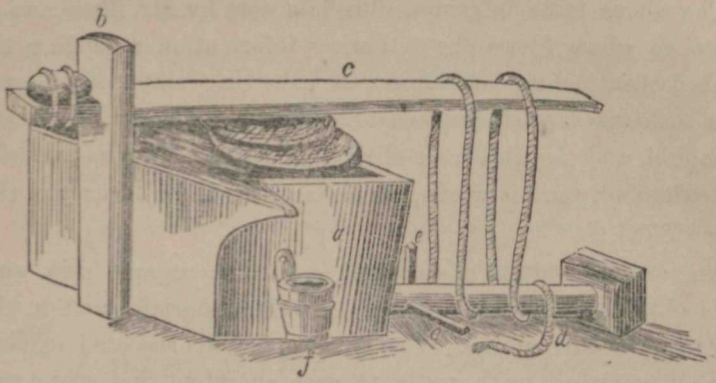

Fig. 5.

It consists of a large square block of wood, *a*, having a shallow depression on its surface for holding the liquid which has run through the bags subjected to pressure. A narrow channel projects from the upper corner to allow the liquid to flow into a tub placed below. The other part of the apparatus is a pressing bar of wood, *e*, that passes through a stout pillar, *b*, erected near the block, carrying a stone at the end of the shorter arm, while the other extremity is connected with a movable rod, *d*, by means of a strong rope. Now when the bags are ready on the bed, workmen alternately trample down one of the boards placed on arms *e e* so as to turn the rod in either direction, at the same time pulling the free end of the rope, whereby pressure is exerted on the bags, sufficient to squeeze out the liquid from them which then flows into the tub *f*.

After the complete removal of the yellow colouring body the pressed mass is pulled apart so as to reduce it to a fibrous condition, and it is then sifted into a tub where it is treated with 1 *sho* of water, and 3 *sho* of the lye above prepared. The whole is now well agitated by the feet of a workman, and again put into bags, which are pressed as before, but this time the liquid is received in a smaller tub, thence it is transferred into a porcelain vessel about 9 *shaku* in diameter, and 1. 2 *shaku* in height, after passing through cotton cloth in order to free it from any suspended matter. The

residue in the bags may be again treated with 5 or 6 *sho* of water, and 5 *sho* of the lye, and the second extract may be added to the main part of the liquid.

If 1 *sho* of the acid be now added, the carthamine is at once precipitated as a very beautiful red powder, which, when allowed to settle, and washed by decantation constitutes what is known as *Shomi beni* (pure safflower) ready to be used for dyeing. When required as a pigment the precipitated safflower is pressed between fine silk cloth (*Habutai*) so as to obtain a paste called *Saiku beni*, to which a little starch made from *Kudzu* is added. A pure kind of the paste, *Komachi beni*, is prepared by dissolving the *Shomi beni* in the alkaline liquid, from which it is reprecipitated by acid, and squeezed through silk cloth as before.

The latter has a much brighter colour than the former, and is principally used as a cosmetic, whilst the other is used for colouring cakes and other materials.

The total amount of the safflower paste thus obtained varies from 7 to 10 % according to the different qualities of cakes from which it is prepared. The price of the two varieties of the paste above mentioned, is at present 10,56 *yen* and 8 *yen* per *kin* respectively.

For dyeing purposes the *Shomi beni* is simply diluted with water to the proper depth of colour which the cloth is desired to be dyed. The process consists in dipping the cloth, which is previously soaked in a mixture of lye and vinegar, and dyed with *Ukon*, into the vat of safflower, where hot water is supplied in case of silk, but cold in case of cotton.

I will not enter upon a detailed account of the dyeing as it rather belongs to another subject.

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2. SHU.

The vermilion prepared in China is most esteemed on account of its high quality, and therefore much is imported from that country, where the native cinnabar is the material from which

metallic mercury is first obtained, which is subsequently converted into vermilion, or red sulphide of the metal.

30 *kin* of powdered cinnabar are placed in an iron pot, heated by a charcoal fire below. This is covered with another inverted pot having a hole at the top from which a bent tube of iron passes into a receiver where the mercury is collected by condensation under cold water. The whole arrangement of the apparatus is shown in fig. 6.

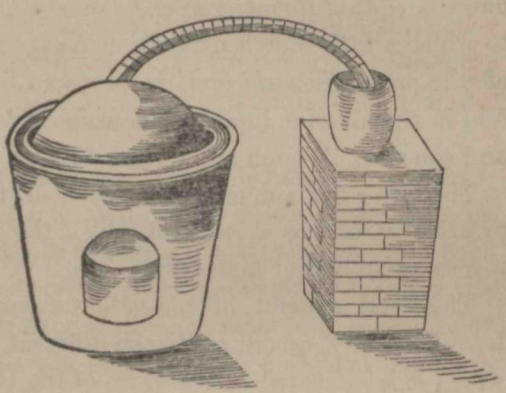

Fig. 6.

The bent tube is carefully bound with ropes, and coated with a mixture of salt and clay so as to prevent any possibility of leakage through crevices, the same precaution being taken at the outside of the still. The heating is continued about 10 hours in order to obtain the whole of the mercury from the ore, and after cooling for a day, the residue is taken out from the still, and a fresh charge introduced, and so on to the next operation.

Now to prepare vermilion 1 *kin* of mercury is mixed with two *kin* of sulphur until no globules of the mercury can be seen, and when heated a black mass is obtained, which is placed in either an iron or an earthenware pot. This is provided with a fixed cover, which pressed down by means of a heavy bar of iron placedupon it.

The upper part of the pot is coiled with iron wire, and the edge is well coated with clay mixture as before. It is mounted on a tripod whose legs are partly immersed into the ground so that there is left sufficient space for heating it by means of charcoal fire, as shown in fig. 7.

After heating for a sufficient time the pot is cooled by throwing water upon it by means of an old brush, and when the cover is removed it will be found that the vermilion has been deposited

on it, as well as on the interior of the pot, the former of which is more beautiful in appearance than the latter. The remaining portion of the sulphur is found at the bottom and may be used again in the next charge. Thus from 1 *kin* of mercury 56 *momme* of the best, and 17 *momme* of the lower kind of vermilion can be obtained, but in order to get rid of the yellow tinge it is subjected to a process of levigation. The lower kind of vermilion is sometimes adulterated with red lead, iron oxide (bengara) &c, giving, of course, an inferior colour.

Fig. 7.

Instead of the artificial product we may have powdered cinnabar which is purified by levigation, and used under the name of *Shin sha*, meaning sand derived from the place called *Shin*, in China. Native cinnabar occurs in Japan principally in Sakaiken, where it was discovered five years ago, at Udagori, in the province of Yamato, yielding not more than 5 *kuanme* in a year.

The manufacture of vermilion is carried out on a small scale at Sakai by a method similar to that described above. It is used as a pigment for the best kind of painting, and also for red ink, but in the latter case it is usually in the form of small sticks, which are then called *Shu-dzumi*.

Various qualities of vermilion are imported from China and Liu kiu Islands. 1 *kin* of a specimen, not the finest, costs 1.2 *yen* at present.

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3. TAN.

It is highly probable that the method of making red lead was first introduced from China about 900 years ago, and the practice was soon commenced by a resident of Sakai, in the province of Idzumi. At present the manufacture is only carried out in that district, where we can obtain three varieties of the substance

known as 1. *Norihisa tan*, 2. *Mituhisa tan*, and 3. *Ichibei tan*, of which the latter two are made from the residue of the first. The whole process of manufacture may be divided into 5 distinct operations: viz. 1. Oxidation of lead by roasting; 2. Crushing of the roasted product; 3. Washing; 4. Drying; and 5. Colouring.

1. OXIDATION.

For this purpose three iron pans, 2 *shaku* in diameter, and 1 *shaku* in depth, are placed on a furnace, which is provided with a separate fire placed just below the roasting pans as shown in fig. 8.

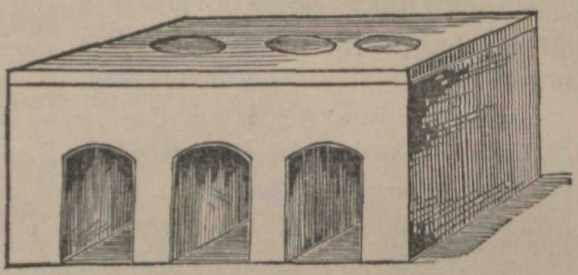

Fig. 8.

While the heating is effected by burning wood as fuel, a quantity of metallic lead is placed in each pan, little by little, until it amounts 150 *kin*, when 7 *go* of alum * are added, about ·5 *go* at a time, and stirred by means of a rod, which produces a brisk kind of ebullition in the pan. If the heating is continued for 8-10 hours and the mass then allowed to cool for some time, lead oxide is produced, which is subjected to the crushing operation.

2. CRUSHING.

This is conducted in an ordinary kind of stone mill, and the powdered massicot having a lighter yellow colour than before, is now ready for

3. WASHING.

This operation is similar to the levigation process described in the case of white lead. The massicot is placed in a wooden tub

* I heard that in one case nitre was added instead of alum probably to assist the oxidation.

into which water is added, and after stirring, the turbid liquid is transferred to a larger tub, where it is allowed to settle for a time. The residue in the former tub contains much impurity, and is therefore thrown away, whilst the washed product is dried in the sunshine to be next converted into minium or red lead.

4. DRYING.

After exposure to the sun shine it still retains some amount of moisture, which is now removed by gentle heating in an iron pan (about 2 *shaku* in diameter, and 7 *sun* in depth) for 24 hours, after which the means is again powdered under a mill stone, and finally passed through a fine sieve.

5. COLOURING.

The finely powdered oxide is put into iron pots, 2 *shaku* in diameter and 3 *shaku* in depth, provided with iron covers, and heated in a furnace similar to that employed in the roasting operation, for four days, when the red colour makes its appearance, thus producing the best kind of tan or *Norihisatan*. The coarser particles remaining in the sieve are treated in the same way without regrinding, and yield the second or third variety as the case may be.

The price of one *kin* of the three varieties of red lead is respectively 22 5 *sen*, 21 *sen*, and 20 *sen* at present, when sold in small quantity. The amount of red lead produced in these works in one year is said to be 10, 000 *kin*, in round numbers costing 1600 *yen*.

It may be used as a pigment especially for painting, and also as an ingredient of some kinds of medicinal plaster, but to only a limited extent.

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4. BENGARA.

The origin of this name is not well understood, though there is an opinion that it is derived from Bengal. Others say that it is

the residue of safflower, hence the name *Beni-gara* is often given to the same substance, but this is not a probable derivation of the word.

It is in fact, red oxide of iron containing more or less silica, alumina, &c as impurities, as the annexed analysis will show.

SiO_2	7.51
Fe_2O_3	88.57
Al_2O_3	1.49
H_2O	2.31
	99.88

It is prepared in Japan to a small extent by igniting *Rokuban*, or native sulphate of iron, in some kind of retort, the sulphuric acid thus expelled being collected and used for various purposes.

Sometimes the native iron oxide is subjected to a process of levigation, and then sold as *Bengara*.

Specimens of such iron oxides were exhibited last year from Kami irinomura in the province of Hitachi, Otakemura in Ugo, Makitanimura in Yechizen, and other provinces of Iwashiro, and Bichu, among which the latter two are said to be the best localities.

It is largely used for wall painting, and also as a red enamel in porcelain painting.

One *kin* of the pigment is sold for 25 *sen*, at present.

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5. SHUDO.

This is a silicious oxide of iron, the name itself signifying "vermilion earth". A specimen was analysed and found to have the following composition;—63% of silica, 30.88% of ferric oxide, 2.5% of water, the remainder being alumina, lime, &c. It is not so extensively used as *Bengara*, though sold at a cheaper rate.

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6. TAISHASUMI.

This is mostly imported from China in small sticks, which are

said to be prepared in the following way:—Native red oxide of iron is finely powdered, and treated with water, by which the earthy matters are removed. The sediment is then boiled in tea decoction, and again pounded in a mortar for some time. It is next transferred to a clean iron pan, and ignited, when a small amount of white bee's wax is added and stirred until an intimate mixture is obtained.

The mass is then thrown into a vessel of fresh water, where it is allowed to digest, and again boiled for a few minutes. The paste is now dried, and made into the required form for use as a brown pigment.

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7. SHOYENJI.

The nature of this substance has hitherto been unknown to the Japanese, as it is always imported from China in the form of flat cakes of cotton by which the red colouring matter has been absorbed.

Some artists believe that it is obtained from the leaves of a plant. Notwithstanding, the colour is very important for them to paint ordinary pictures, as, being soluble in water it presents no difficulty in manipulation, and moreover the colour is very beautiful.

In studying this substance in an aqueous solution I have found the following reactions:—1. Hydric chloride or sulphate produces no change of colour, but when heated, turns the liquid to yellowish red.

2. Ammonia renders the colour darker, and gives a purple tinge.

3. Lead and zinc acetates give red precepitates.

These reactions exactly correspond to those of carmine, which is a kind of lake prepared from cochineal. On further examination I found the following results:—

1. Total extract from the original substance .... 31.4 %
2. Total extract from the powder detached from the cotton .... 42.66 %
3. Total ash from the original substance .... 10.56 %
4. Total ash from the powder detached from the cotton .... 14.00 %
5. Soluble ash from the original substance .... 9.83 %
6. Soluble ash from the powder detached from the cotton .... 13.33 %
7. The ash consists of alumina, sulphuric acid and alkaline carbonate, in which I found 16.22 % of alumina.

These experiments show that the *Shoyenji* consists of a carmine lake obtained by the use of alum and alkaline carbonates, probably from wood ash, upon a cochineal extract so as to fix it on the fibre of cotton. But no definite information could be obtained on this subject.

III. BLUE PIGMENTS.

In this group we have the following substances :—

1. Ai (indigo).
2. Konjo (blue carbonate of copper).
   a. Iwa konjo.
   b. Iwa gunjo.
   c. Iwa biyakugun.
3. Hanakonjo (smalt).

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1. AI.

This substance has been known in Japan from a very early period, and forms at present one of the most important materials both for dyestuffs and pigments. It is mostly obtained from the *polygonum tinctorium*, which is known as *Tade-ai*, but whether this plant is a native of Japan or was formerly brought from China is a matter of uncertainty.

It seems that the substance used in olden times was rather different from the present indigo, but was probably a variety called *Yama-ai*, derived from the *mercurialis leiocarpa*.

The indigo plant grows in many parts, among which Yamashiro, Yamato, Kawachi, Mino, Kotsuke, Mutsu, Harima, and other provinces in the southwestern part of the Empire are the principal districts in which it is cultivated. There are two ways of cultivating the plant, one is in a rice-field, that is in wet ground, and the other in a vegetable field.

The latter method is principally carried out in the celebrated indigo district at Nakanoshima in the province of Awa, where we have 5 varieties differing from each other in the form of leaves, although their flowers and seeds are in respects similar.

The first one is called *Ako-ai*, the second *Awa-ai*, the third *Riomen-ai*, the fourth *Hiyakkuan-ai*, and the fifth *Fukuha-ai*. The seeds (which cost 25—30 yen per *Koku* in this district) are first

steeped in water, or in tea decoction, for 5 or 6 days, then spre over a sheet of matting for one night. On the next day (usuall the beginning of February) they are sown, the ground bein previously well turned up and levelled.

After 20 or 25 days, when germination has taken place, th ground should be carefully manured from time to time durin their growth. Generally after 75 days from the time of sowing the young shoots grow to 6—8 *sun* in height, when they a transferred to the proper plantation, where wheat and beans a also cultivated.

The first crop of leaves is obtained in the middle of July, an the second one about 30 days later from the same plants The leaves so obtained are carried to a store house, where they are divided into 3 qualities, and cut separately by hatchet (*Nata*) into very fine pieces, which are spread ove mats, and dried for half of the next day, until the mass become darker in colour, when the stems are removed, and the tru leaves preserved in straw bags. This is called *Kiri-ko*, o "powdered by cutting."

Another way is to cut the secondary leaves early in the morning, dry them in the sun shine, and transfer to a store house in the afternoon. They are now beaten by means of a pole until about 2 o'clock of the following day, so as to separate them from the stems which are subsequently removed, and the dry leaves preserved as before. This is called *Uchi-ko* or "powdered by beating." In this way 40—20 *kuanme* of the first leaves and 16—8 *Nuanme* of the secondary leaves are obtained from 1 *tan* or 300 *tsubo* of ground.

In order to make use of the indigo for dyeing and other purposes, the leaves are subjected to a peculiar kind of fermentation by repeatedly moistening them with water for about 80 days, during which the best kind is treated 25 times, the medium 15—16 times and the lowest, 8 or 9 times, with the requisite quantities of water.

This varies according to the nature of leaves, but as a rule 100

Kuanme of leaves require from 2.5 to 1. 7 *Koku* of water at the first time. When once moistened they are covered with mats, and left for 4 days for the best, 6 days for the middle, and 9 days for the lowest quality, and the process is repeated with an amount of water diminishing each time, during which the mass is turned over so as to expose all parts to the action of water and air. This is a very important part of the operation, and requires great skill, for either an excess or a deficiency of water would render the indigo almost valueless for dyeing purposes, so that such indigo is sold at very much lower prices.

When water has been added beyond the required amount the workman says "*Sameru*," while if deficient he calls it "*Yakeru*."

Now with regard to the preparation of *Tama-ai* (ball indigo), 3.5 to 4.3 *Kuanme* of properly fermented leaves or *Sukumo*, as it is called, are pounded in a mortar with the addition of a little water for 2 days, ½ day, or ⅓ day according to the quality from the best to the lowest, thus forming a sort of paste, which is then placed on a board and made into balls by hand, from 20—25 in number.

When dried they are kept in straw bags, and sent into commerce. Each bag contains 10. 8 *Kuanme* of indigo ball and costs 67.59 yen for the best, but only 5,40 yen for the lowest kind. The amount of the *Tama-ai* produced in this district in the year 1871 is said to have been 197,828 *hiyo* (or bags) which is equivalent to 2,136,542.4 *Kuanme* by weight.

It will be seen from the process described above that the *Tama-ai* is nothing but crude indigo which has been produced from the glucoside, existing in the leaves, during the fermentation by the action of water and oxygen. It therefore contains a large amount of vegetable matter useless for any purpose.

The author of *Keizai Yoroku* informs us that a kind of sand called *Shusha* (鉄砂) is a necessary material in the preparation of the tama-ai, and if this is not added the leaves will undergo putrefaction and turn black instead yielding a blue colour. That, the sand has a dark brown brown colour like rust, and the best

kind occurs in Awa, and also at Unakami in Shimosa, so that if we use this substance obtained from the latter district we shall get the best quality of indigo. Supposing this to be iron oxide, in what way it acts on the indigo I am not able to explain, unless it is used as an adulteration to increase the weight.

The disadvantages of this method over that carried out in India may be enumerated as follows :—1° It takes a very long time, at least 80 days for one operation, so that there is a danger of destroying the quality of indigo by over fermenting, as before stated. 2° If too much water is added at a time the glucoside will be dissolved out before oxidation, hence a loss of indigo will arise. 3° The result of these operation is a substance containing only a very small percentage of real indigo. It therefore occupies a greater bulk for a given amount of indigo, and thus adds greatly to the cost of transport.

Now let me pass on to the preparation of *Airo* (or indigo wax) which is used as a pigment.

This name refers both to the pure indigo blue, and to that mixed with starch forming a pasty mass. The former is mostly used by dyers for the purpose of printing indigo on stiff cloth, which can not be easily dyed in the ordinary vat.

Its preparation :—A thick piece of cloth made of *Asa* is repeatedly dyed with indigo in a vat until a sufficient amount of the dyestuff has been taken up by the cloth, which is then dried, and washed in water so as to remove impurities.

If it is now rubbed vigorously by the hand in a vessel containing water, all the indigo will be separated out from the fibre, and is then dried and kept for future use, while the cloth can be again dyed as before. In order to fix this indigo on stiff cloth the fine powder is diffused in water, and spread over the cloth by means of a brush, while the piece is stretched on a board or by means of string and bamboo sticks. This form of indigo is called by dyers "*Zoku*."

The pasty form of indigo is prepared by collecting the scum of a vat, and mixing it with starch either from rice or wheat.

Sometimes indigo is obtained from rags by boiling them with an alkaline liquid, and afterwards collecting the scum so obtained, and mixing it with starch as before. I have examined a specimen of the paste, and found the following results:

Water	58.85
Indigo	7.15
Ash	6.75
Starch	6.21
	78.96

The difference from 100 is probably due to some organic matter derived from rags, starch paste, or from some other source in the manufacture.

When, however, I heated a small amount of the indigo paste with soda lime not much ammonia was evolved showing that no large amount of albuminous matter was present.

So far as the use of this pigment is concerned it will not be of any great importance to know its exact constituents, and further, I had not sufficient time to carry out experiments on the subject. The ash was completely soluble in acid, and consisted mainly of calcic carbonate.

The price of 1 *kin* of the paste is 48 *sen* at present. This form of indigo is principally employed in printing cloth instead of dyeing.

The best kind of indigo used for painting is imported from China in the form of small cylinders.

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2. KONJO.

This body is called under different names, such as *Hensei*, *Taisei*, *Sekisei*, *Tensei*, &c. according to different authorities, but is commonly known in this country by the general name of *Konjo* or *Gunjo*. On account of its being obtained from a mineral it is usually called *Iwakonjo*, or *Iwagunjo* (*Iwa* meaning a rock), of which the former name is more especially applied to a coarse pow-

der having a deep blue colour, while the latter commonly refers to a variety having a lighter tint.

The mineral from which it is obtained is called *Kujaku-ishi*, which name is applied both to azurite (blue carbonate of copper) and to malachite (green carbonate of copper).

An old record informs as that in the 6th year of Wado (714 A. D.) under the Empress Genmiyo, a specimen of *Konjo* was presented to her majesty from the province of Kotsuke, and also in the 2d. year of Chokin, (1041 A. D), under the Emperor Shujakuin the same mineral was offered from Settsu, and more recently in the Keicho period, (1596—1614), azurite was discovered in the silver mine of Tada in Settsu. From this time both carbonates have been found in many places where copper occurs in greater or less quantity, so that blue and green pigments are now mainly prepared from these minerals, while in former times they were principally imported from China.

The principal localities, in which they occur are Ani in Ugo, Hon-iwa in Yechigo, Mayehira and Mitaniyama in Hida, Kiura in Bungo, Ashiwo in Shimotsuke, and also in the province of Nagato.

The exact process by which the pigments are made from these minerals is kept secret by the manufacturers, but a general outline of the process may be given as follows:—

First of all the minerals are washed with water so as to remove earthy matters as much as possible, and then crushed in a mortar to a certain degree of fineness. The powder thus obtained is placed in a tub containing water, and by agitation the lighter portion will be diffused through the water, while the heavier particles rapidly sink to the bottom, and are separated from the other parts by decantation. The coarse powder when dried has a deep blue or green colour according to the nature of the mineral, and gives a blue pigment, *Iwakonjo*, or the green variety, *Iwarokusho*, which will presently be described.

The finer portion is allowed to settle in another tub, and is again separated from the finest particles by a similar process, and

so on to get powder of different colours, the finer the particle the lighter the colour will be.

These varieties are sold in shops under different names, the next lighter blue to *Iwakonjo* is called *Iwagunjo*, and the lightest blue goes under the name of *Iwabiyakugun* or *Usugunjo*. Such natural colours are more esteemed by Japanese artists than other blue pigments which are prepared artificially, as smalt or ultramarine, although they are inferior in colour to them.

I have estimated the amount of copper in *Iwakonjo*, *Iwagunjo* and *Iwabiyakugun*, and obtained the following percentages:—

	Iwakonjo	*Iwagunjo*	*Iwabiyakugun*
Copper	49.15	48.5	29.

The difference in the last variety is due to the presence of *smalt*, probably added for adulteration, which together with silica amounted to 37.71%. Now calculating the amounts of the blue carbonate from these of copper above given I found,

	Iwakonjo	*Iwagunjo*	*Iwabiyakugun*
$2\,CuCO_3 \cdot Cu H_2 O_2$	89.2	88.01	52.63

The difference from 100 consists of inpurities, silica, alumina, ferric oxide, lime, water in combination with silica, &c.

The price of 1 *kin* of these pigments varies from 60—80 yen. From their very high price they can not be used for general painting, except for pictures which have to be highly ornamented. In such cases they are mixed with glue as a vehicle.

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3. HANAKONJO.

No certain information of the manufacture of this substance has been obtained at present. It is said that it may be prepared by fusing crude oxide of cobalt with a mixture of clay and alkalies, so as to form a kind of blue glass, or smalt.

At present foreign smalt is largely used, being sold at a cheaper rate.

IV. GREEN PIGMENTS.

In this class I have to consider the malachite green which has been already referred to amongst the blue pigments. It has been known by several names *Sekiroku*, *Tairoku*, *Rokusei*, &c. but the pigment is commonly called in this country by the name *Iwarokusho*, of which there are several varieties distinguished according to the depth of their colours. Thus No. 1 *Iwarokusho* is the name given to a coarse powder having a deep green colour, No. 2 to that of lighter colour, and so on to No. 3 or 4. The finest variety having the lightest green colour is called *Iwabiyakuroku*, or *Biyakurokusho*.

The mode of preparation of such pigments from the mineral is exactly the same as that described in case of Azurite. I have only examined two specimens of the green, and found the percentage amounts of copper as follows :—

	Iwarokusho	*Iwabiyakuroku*
Copper	41.25%	48.15

Calculating the amounts of the green carbonate from these numbers I have,

	Iwarokusho	*Iwabiyakuroku*
$CuCO_3 + CuH_2O_3$	72·02 %	84.07 %

The price of 1 kin of these pigments is 8 yen, so that they are very much cheaper than the blue variety which is not so abundant.

For ordinary painting we use a mixture of indigo and the yellow pigment *Shiwo* rather than the mineral greens.

There is a substance known under the name of *Doroku*, which is prepared by sprinkling vinegar over plates of copper which are then kept in a warm place. The verdigris thus formed on the surface of the metal is collected from time to time, and powdered. But this is not an important pigment, being scarcely used in painting.

V. YELLOW PIGMENTS.

Under this class we have,

1. Shiwo (gamboge).
2. Sekiwo (orpiment).
3. Zumi paste.
4. Odo (yellow ochre).

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1. SHIWO.

This name has been incorrectly given to a kind of resin obtained from a plant known as *garcinia morella*. It should be properly called *Towo* to distinguish it from another body having the same name *Shiwo* (雌黃) which is native orpiment, or sulphide of arsenic. Gamboge is always imported from China in the form of cylinders, which being ground with water are used as a yellow pigment.

In China it is obtained by making several incisions in the stem of a tree called *Kaito*, which grows on the mountains of some districts, and collecting the liquid which thus flows out in a mould.

One *kin* of gamboge is sold at the rate of 1.35 *yen*. It is highly probable that the plant could be cultivated in Japan for the production of such a useful pigment.

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2. SEKIWO.

On one occasion (about 32 years ago) a resident of Aidzu in the province of Iwashiro made an experiment by burning arsenical stones, known to him as *Yoseki*, with sulphur, in order to prepare a substance called *gosu* which was very largely imported from China, being employed for an enamel colour, believing that the gosu, or crude oxide of cobalt, could be made from *Yoseki*, which was very abundant in that district.

But as the result of his experiments, he found that a yellow sub-

stance was formed which was afterward discovered to be the same as *Sekiwo*, or *Kiwo* as it is sometimes called, which had been previously imported from China. This led him to prepare the yellow pigment rather than that which he expected to produce. He then carried out the manufacture on the large scale in the mountains, but from the poisonous effect of the gases evolved during the operation, many of the workmen suffered disease, so that a slow combustion was then allowed to proceed after having once ignited a mixture of the arsenical ores and sulphur. The end of the operation was determined by practice from the colour of the smoke, so as to avoid danger to the workmen.

The *Sekiwo* so obtained is, however, inferior to that of China, and is therefore sold much cheaper.

At present 1 *Kin* of *Sekiwo* costs 42 *sen*. It is usually mixed with lacquer and used as a yellow varnish. It is also used for painting the covers of Japanese books &c.

An analysis of one specimen showed that it contains 48.1% of sulphur in which 2.5 % is in a free state which is soluble in carbon disulphide, so that 45.6 % of sulphur exists in the combination with arsenic in the form of $As_2 S_3 \cdot As_2 S_5$, that is $As S_2$. I found no arsenious acid ($As_2 O_3$) in the sample.

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3. ZUMI PASTE.

This is prepared from the extract of the bark of a tree called *Sawanashi*, belonging to the genus *Pyrus*, which grows in Kai, Shinano, Shimotsuke, Kotsuke, Yechizen &c. The dried bark is first cut into small pieces which are then mixed with strong potash lye obtained from wood ashes.

On pounding the mixture the yellow colouring matter of the bark is dissolved, which is now precipitated by adding alum to it, and is afterwards mixed with starch paste for use as a yellow dyestuff, and as a pigment. Unfortunately I have not had sufficient time to enter upon a minute examination of the colouring matter.

But when the bark was treated with alcohol the colouring matter was not dissolved to any great extent. If, however, it was boiled with an alkaline liquid a dark brown extract was obtained which when mixed with acids gave a brownish floculent precipitate like ferric hydrate, insoluble in excess of the acids.

The paste is sold under the name of *Norizumi* at the rate of 1.6 *yen* per *kin*.

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4. ODO.

The name simply means yellow earth, and it is a hydrated yellow oxide of iron. It occurs principally in Settsu, Musashi, Owari, Mino, Uzen, Inaba, Suwo, Sanuki &c.

It is sold in the form of small plates, being used as a red enamel on porcelain, and also for other paintings, and as a medicine.

The following analysis was made by Mr. Takayama during the last session :—

SiO_2	51.34
Fe_2O_3	18.11
Al_2O_3	19.17
CaO	2.06
MgO	.96
K_2O	1.31
Na_2O	1.61
H_2O	5.07
	99.63

From this analysis it is evidently a mixture of clay and iron oxide.

VI. BLACK PIGMENT.

Under this head I have only to describe the manufacture of *Sumi*, or lamp black, which is used as a black pigment either in the state of powder, or in the solid form by mixing it with glue (*nikawa*), constituting what is known as Indian ink. The latter form is usually adopted for writing as well as for drawing, while the former is used only for printing and wall painting.

With regard to its history it is said that in the 18th year (610 A. D.) of the reign of the Emperor Suiko, a priest named Doncho came from Corea, who was acquainted with the preparation of *Sumi* and paper. From this time the method of *Sumi* making is said to have been known in this country.

It seems, however, that the practice was commenced at a much later period, not more than 270 years ago. It was under the Emperor Goyosei (1587-1612) that soot was collected by burning pine trees at Kaibara in the province of Tamba, for the purpose of making the solid ink properly called *Shoyenboku*, which means ink prepared from the soot of the pine tree. Since that time similar works have been extended through the mountainous regions in Ise, Mikawa, and Kii, where old pine trees are very abundant.

The process as now conducted at Kumano in Kii is the following:— On the slope of a mountain is erected a shed, 60 *shaku* long, 18 *shaku* wide, and 7 *shaku* high, and in which are arranged prismatic frame works of wood 14 in number, each of them being provided with door sashes at all sides and the top, that are covered in the interior with paper for the deposit of soot evolved from a small furnace placed inside as shown in fig 9. The furnace is made of earthen ware, about 1 *shaku* high, and 1 *shaku* broad, for the lowest, .8 *shaku* by .8 *skaku* for the middle, and .6 *shaku* cube for the best kind of soot to be collected.

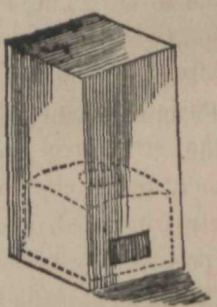

Fig. 9.

Near the bottom of the front side of each frame there is a rectangular mouth

through which sticks of pine trees are introduced into the furnace, a piece being 2 *sun* in diameter, and 6 *sun* in length. After incomplete combustion has gone on for 6 days the soot which has been collected on the surface of the paper is detached by means of a feather, thus in the average 3 *kin* of the best, 4 *kin* of the middle, and 6 *kin* of the lowest kind of soot can be collected in one day by four workmen, but the amount of pine wood thereby consumed is not known.

The best kind of soot is, however, prepared from the sesamum oil; the process is extensively carried out in the famous works of *Kobaiyen*, at Nara, in the province of Yamato. Here the practice was begun in the Keicho period (1596-1614 A. D.), but before this time it was worked at Toichigori in the same province, beginning from the Tensho period (1573-1591 A. D.).

The present building of wood is about 13 *shaku* long, 10 *shaku* wide, and 7 *shaku* high at front. It contains two series of shelves placed one above the other at a distance of 2 *shaku* along the inner sides of the chamber excepting the front one. On these shelves, which are coated with clay, a number of small earthen dishes (about 200) are placed side by side containing the oil to be converted into soot.

A slight elevation is made around each dish except at the front, over which an earthen cover is placed to collect all the soot evolved from the burning of the oil contained in the dish, the depth of which is such that there is a distance of two *sun* from the bottom to the cover. The wick used for this purpose consists of ordinary *toshin*, twisted together.

After allowing the combustion to proceed for some time, when a sufficient amount of soot has been deposited on the under side of the cover it is carefully brushed upon paper by means of a feather, and finally collected in a box. If the oil is found to be nearly consumed, another charge is placed in each dish, so that the process may be continued through the whole day.

The quality of the soot varies according to the time of preparation, the best kind, which has a bluish tint, is obtained in the

spring and autumn, for in other parts of the year, when the temperature is too high or too law, the quality of soot is said to be inferior to that prepared in a temperate season.

The soot obtained is liable to contain some volatile oil, which can be removed by gently heating it in a vessel of any shape we please.

It is sometimes necessary to subject it to levigation in order to get a purer kind of lamp black, which is then mixed with glue for the preparation of the solid ink. This is done as follows :—

A board of pine tree about 3 *shaku* square is laid down over a small fire place, which serves to keep the glue in the liquid state while being mixed with lamp black on the board. First of all, place one *kin* or 160 *momme* of the refined dry soot on the board, and pour over it about 32 *momme* of melted glue, mix well and knead them forcibly with the hand. A small amount of scent such as camphor, musk, cloves &c, and some colouring matter, as safflower or brazil wood are now added and the mass is again kneaded, when it will assume a shiny appearance.

The cake is then ready to be placed in a mould consisting of three rectangular pieces of wood usually of *Biwa* or *Nashinoki*; the middle one is provided with the required space, and of the thickness for the bar of ink to be made, whilst the upper and lower ones are engraved with certain figures and letters to be disigned upon it. If it is required to put gold or silver leaves on the ink as an ornament, the cake before being introduced into the mould must be covered with them. After a number of pieces have been taken out from the mould, they are subjected to drying.

The drying apparatus consists of a wooden box, 3 *shaku* long, 1.5 *shaku* wide, and .3 *shaku* high, containing well sifted wood ashes to the height of 6 *bu* (.06 *shaku*) from the bottom, over which several sheets of paper are placed for the bed of the pieces to be dried, that are covered with another layer of ash about 7 or 8 *bu*, thus keeping them in a quiet place. A fresh quantity of ash is replaced twice in a day for three days, when the corners of each piece are carefully cleaned with a knife and again placed in ash

for two days longer, but for large pieces it requires 7 or 8 days for complete dessiccation. They are then placed in heaps between two planes of boards which are pressed by means of strings, so that any distorted pieces may be brought to the right shape, and are further dried by suspending them in a windless place for 5 or 6 days, after which every 10 pieces are folded in paper and again suspended in a place with a free current of air for 10 months, and are lastly preserved in a closed box made of *Kiri*.

In order to polish their surfaces well dried pieces are rubbed with the bark of the palm tree, or sometimes with horns, or skins of some animal. It is said that the quality of the ink is much improved after keeping for many years, showing purplish black colour, but care should be taken not to allow them to become moist during the preservation. For this purpose they are taken out from the box once a year usually after the rainy season has passed, and exposed to the air for some time.

No certain information was obtained as to the amount of ink produced from a given amount of lamp black, nor as to the expense of manufacture, but the following numbers are found in the report of the last Tokio exhibition :—

The amount of ink made in one year in *Kobaiyen's* Work.	126,696 pieces,
The total cost	4230.25 yen.

The price of the finished product varies very considerably according to the quality as well as to their size, and depends upon the relative amount of lamp black obtained from the oil and from the pine tree, which the ink contains, the lowest sorts containing 90% of the latter, and 10% of the former, whereas in the finest sorts they are mixed in equal proportions.

The use of this substance in Japan is undoubtedly very extensive for writing and drawing purposes, while the powdered soot is largely employed for wall painting as well as for printing.

ENAMELS.

We are indebted to Mr. Namikawa of Kioto for specimens of the enamels used in his *Shippo-works*, which we had an opportunity of visiting in February of this year (1878).

I have been engaged for some time in making analyses of these important pigments, the results of which are perhaps sufficiently interesting to be given in this part of the paper.

1. HINO-OKASEKI.

The analysis shows it to consist mainly of silica, although I found a small amount of alumina in the sample. This substance is said to be obtained from the place called Hinooka, a small village in the eastern part of Kioto, hence the name, *Seki* meaning a stone. It is sold as a very fine white powder and is used for the purpose of decreasing the fusibility of an enamel.

Analysis.	
SiO_2	98.89
Loss on ignition	.23
	99.12

2. SHIRATAMA.

This is nothing more than powdered lead grass, which is completely decomposed by aqua regia, leaving silica only insoluble. It is used as a white enamel.

Analysis.	
SiO_2	49.05
PbO	36.91
$Fe_2O_3 + Al_2O_3$	.50
CaO	.62
K_2O	11.85
Na_2O	.65
	99.58

3. TONOTSUCHI.

It has been already stated under the head of *Oshiroi* (Page 5) that *Tonotsuchi* is pure white lead whose composition approaches very nearly that prepared by the Dutch or German Method.

This body is only added for the purpose of giving fusibility to the enamel.

4. KOISEI.

	Analysis.
Si O^2	47.84
Pb O	31.19
Cu O	8.43
$Fe_2 O_3 + Al_2 O_3$	.52
Ca O	.63
$K_2 O$	11.19
$Na_2 O$	.56
	100.36

This name indicates a deep green, although strictly speaking, *sei* means blue. In fact it is a green powder, decomposable by aqua regia ou protracted boiling into silica and soluble salts of the metals. The composition, as the analysis shows, is similar to that of lead glass with the addition of copper oxide, which in combination with silica, imparts a gaeen tinge to the enamel.

5. USUSEI.

	Analysis.
Si O_2	53.65
Pb O	29.63
Cu O	2.50
$Fe_2 O_3 + Al_2 O_3$	.38
Ca O	.96
$K_2 O$	11.04
$Na_2 O$	1.62
	99.78

As the name indicates this is a lighter green powder, the nature of which is similar to that of *Koisei*

With regard to the composition, the amount of copper oxide is much less than that existing in the former sample, an l therefore the product has a lighter green tint.

6. MURASAKI.

This is also a powdered glass having a pink colour due to manganous silicate, and similar in all other respects to the green enamels previously described.

It will be seen from these analyses that the three coloured enamels, *Koisei*, *Ususei*, and *Murasaki* are probably made from *Shiratama* by adding metallic oxides in a form of frits, and afterward fusing so as to obtain coloured glass. But different samples of the lead glass from which they are prepared may not have the same composition as that above given, so that there may be slight differences in the proportional amounts of each constituent.

Analysis.

Si O	50.52
Pb O	32.05
$Fe_2O_3 + Al_2O_3$	.45
Mn O	3.93
K_2O	12.22
Ca O	.62
Na_2O	.18
	99.97

7. KONJO.

Although the name *Konjo* is given, it is not carbonate of copper, but smalt, as the analysis indicates.

It is therefore the same substance as *Hanakonjo* which has been previously mentioned under the class of Blue Pigments. It has a very deep blue colour, and is quite insoluble in acids. When used as a blue enamel it is mixed with *shiratama*, *Tonotsuchi*, and *Hinookaseki* as will be shown in the receipt.

Analysis.

$Si O_2$	69.67
Co O	7.06
$Fe_2O_3 + Al_2O_3$....	4.50
K_2O	18.32
Na_2O	.61
	100.16

8. BENGARA.

The nature of this substance has been already described under Red Pigments (Page 19).

It is used as a red enamel with *shiratama* and other substances.

9. IYOSHIROME.

On examination I found that this consists of nearly pure anti-

mony obtained from the province of Iyo. It is also called *Toshirome*, and is used as a yellow enamel with *Shiratama* and other bodies, whereby oxides of antimony and lead are formed which give the yellow colour.

Having studied these materials let us now consider in what way they are used in order to produce the desiree colours on *Shippo* ware.

Mr. Namikawa told us that the proportions in which they are mixed vary according to the different tints of each enamel, but the following receipt may serve as specimens of various mixtures :—

WHITE ENAMEL.	Momme
Shiratama	50
Tonotsuchi	7
Hinookaseki	7

BLUE ENAMEL.	
Konjo	7
Shiratama	50
Tonotsuchi	7
Hinookaseki	7

GREEN ENAMEL.	
Koisei or Ususei	50
Tonotsuchi	7
Hinookaseki	7

YELLOW ENAMEL.	
Iyoshirome	45
Shiratama	50
Tonotsuchi	7
Hinookaseki	7

RED ENAMEL.	Momme
Bengara	7
Shiratama	50
Tonotsuchi	7
Hinookaseki	7

BLACK ENAMEL.	
To gunjo *	7
Shiratama	50
Tonotsuchi	7
Hinookaseki	7

PINK ENAMEL.	
Murasaki	50
Tonotsuchi	7
Hinookaseki	7

YELLOWISH GREEN ENAMEL.	
Ususei	50
Toshirome	15
Tonotsuchi	10
Hinookaseki	10

* *Togunjo* means ultramarine, which, containing a large amount of sulphur produces lead sulphide when heated with lead car-

bonate and lead glass, thus imparting a black colour to the enamel. The way in which these colours are fixed is as follows:—Certain figures are designed on a copper or silver ground, and fine wires either of brass, copper, gold or silver are fixed on them by means of glutinous matters derived from *Yamanoimo*.

The whole is then covered with a layer of fusible metal so as to make them immovable, and washed with acid plum juice for the purpose of dissolving out any impurities on the surface. The figures are then coloured with the various mixtures above given by means of a brush, and after this the article is baked twice in a furnace, and polished by means of a coarse grinding stone. Colours are again put on and baked for the third time. It is afterward polished with smooth grind-stones, and finally with charcoal made from *Honoki*, whereby the surface becomes very bright, rendering the wires visible in the midst of the enamel.

This mode of ornamenting metallic or porcelain wares is called *Shippoyaki*.

My friend Mr. W. Watanabe, a student in the mining department, has kindly given me the following receipts for the enamels used in the celebrated porcelain works of Kutani, in Kaga.

Here the blue colour is used is of two kinds, that for colouring *Suyaki* or biscuit is either smalt or *Chinese gosu*; the former is too deep a blue, which Japanese do not esteem much, while the latter is too faint, therefore a mixture of the two is used according to the colour required.

1. 1 part of smalt (3 to 8 *yen* per kin) is mixed with 9 parts of *Tonotsuchi* so as to make 10 parts of a moderate colour which is again mixed with a certain amount of *Chinese gosu*. For using the mixture water is added, and certain designs are drawn over the *Suyaki* by means of a Japanese brush, and a afterward glazed.

2. Blue for colouring above the glaze is made of

Konjo (Carbonate of copper).	2	*momme*
Tonotsuchi	5.2	„
Shiratama	3.6	„

3. GREEN ENAMEL

Rokusho (Carbonate of copper)	4	„
Shiratama	10	„
Tonotsuchi	10	„

4. RED ENAMEL.

Bengara	10	*momme*
Shiratama	25	„
Tonotsuchi	5	„
Hinookaseki	6	„

5. YELLOW ENAMEL.

Bengara	0.6	„
Shiratama	10	„
Tonotsuchi	7	„

6. FAINT PURPLE ENAMEL.

Kawaragosu or ($Mn O_2$)	2	*momme*
Shiratama	10	„
Tonotsuchi	7	„

7. SCARLET ENAMEL (Called *Yenji*)

Finely powdered gold leaves	.5
Shiratama	10
Tonotsuchi	5
Hinookaseki	10

8. DEEP PURPLE ENAMEL.

This is obtained by adding a certain amount of *Konjo* to the 7th mixture.

9. BLACK ENAMEL.

A paste of binoxide of manganese in water is first drawn over

the glazed porcelain, and after it is dried, it is coated with a mixture of *Shiratama* and *Tonotsuchi*.

10. If the wares which have already been coated with enamels are to be painted with gold we must select the best leaves, and powder them in a porcelain mortar for 4 days, a little water being added from time to time. The powdered gold is then painted on the ware according to the design, and the whole is again baked, and afterward polished by means of a steel piece which is slightly bent at the top as shown in fig. 10.

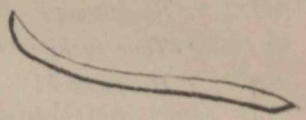

Fig. 10.

But at present steel is superseded by agate.

After polishing for a long time the true golden colour appears.

What is called *Awasekin* consists of 1 *momme* of gold, and 0.1 of borax. When this is used the result is not so bright as that of the pure gold, so that it is used for producing a different tint from gold.

The following receipts for enamels used for Rakuyaki have been given by an acquaintance :—

The *Sayaki*, or biscuit, is first coated with a mixture of 10 *momme* of *Shiratama* and 7 of *Tonotsuchi* made into a paste with *Funori*.

After drying in the sun shine it is again coated mith the mixture, and then with one of the following mixtures ;—

1. BLUE.

Konjo	1	*momme*
Shiratama	.5	„
Tonotsuchi	.3	„

2. RED-

Odo	1	„
Bengara	.2	„

Hinookaseki	.2	„
Tonotsuchi	.3	„

3. PURPLE.

Purple *gosu*	7.	„
Tonotsuchi	10	„
Hinookaseki	2	„

4. YELLOW.

Shiratama	9	„
Tonotsuchi	10	„
Hinookaseki	.25	„
Iyoshirome (antimony)	.6	„

5. BLACK.

Kurogosu (binoxide of manganese)	6	„
Tonotsuchi	1.5	„

6. GREEN.

Shiratama	10.	„
Tonotsuchi	10	„
Rokusho	4	„

After being painted with such a mixture it is dried and again coated with upper glazings which are given below.

1. WHITE UPPER GLAZE.

Hinookaseki	35 - 4	*momme.*
Tonotsuchi	10	„

(Made into paste with *funori*).

2. GREEN UPPER GLAZE.

Tonotsuchi	10	*momme*
Rokusho	2	„
Shiratama	1	„
Hinooka	3	„

3. YELLOW UPPER GLAZE.

Tonotsuchi	10	„
Hinookaseki	3	„
Odo	1.5	„
Shiratama	4	„
Iyo shirome	.3	„

4. BLACK UPPER GLAZE.

Rokusho	7	„
Bengara	2	„
Hinookaseki	1	„
Shiratama	10	„
Tonotsuchi	7	„

I have examined a sample of the black glaze and found that it consists mainly of silica (64.52 %) and iron oxide (16.08 %), the other constituents being small amounts of manganese, lime, lead, and carbonic acid, so that the black here produced is probably due to a peculiar combination of silica with iron which has been proved by experiment.

The lead and carbonic acid indicate the presence of *Tonotsuchi* as is seen in the receipt 5.

1. Hon zo ko moku. 本草綱目
2. Tenko kai butsu. 天工開物
3. Wa kan san sai dzu ye. 和漢三才圖繪
4. Dzu gua sei go. 圖畫正誤
5. Ko bai yen boku dan. 古梅園墨談
6. Man kin san gio bukuro. 萬金產業袋
7. Kei zai yo roku. 經濟要錄
8. Report of the Kuangiyo Hakurankuai. 內國勸業博覽會報告書
9. Diagrams-Illustration, published in Hakubutsu kiyoku. 博物局出板諸物圖
10. Nipon san kai mei butsu dzu kuai. 日本山海名物圖會